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ABSTRACT

This symposium report probes the barriers within special education that slow research utilization and examines positive influences on attitudes toward conducting research in practical settings. The first section presents five categories of barriers to technology implementation, outlined by Joel Mittler. Barrier categories include equipment, implementation, teacher training, teaching as a profession, and classroom environment. The second section describes factors in the success of four technology programs. Edward Blackhurst outlines the development of professional standards with respect to technology, certification and licensure standards, identification of technology skills, and teacher training. Steven Robinson describes the experience and research of the Amherst H. Wilder Foundation which indicate technology's potential in creating a powerful instructional environment. The University of Washington's approach, involving development of a grassroots network of support for classroom technology, is discussed by Owen White. Harriet Copel emphasizes that implementation requires an understanding of what motivates the individual teacher and how technology can help in each individual classroom situation. The final section of the report consolidates the thinking of the symposium participants during the process of identifying implementation barriers and possible solutions. (JDD)

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Advancing Technology Use: Barriers to Research Utilization

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Preface

he Center for Special Education Technology at The Council for Exceptional Children is a national information center funded by the U.S. Department of Education, Office of Special Education Programs. The Center's broad goals are to influence the quality, availability, and use of technology in special education through information. To that end the Center provides a range of information services and activities for educators, developers, and publishers.

The Center for Special Education Technology sponsored its annual invitational technology symposium in June 1989. Attendees included researchers, publishers, developers, trainers, and special education supervisory personnel, with the symposium serving as an outreach from researchers to commercial product developers and practitioners. The mix of attendees allowed the interactions and discussions to focus on both research utilization and research production.

The opening session of the symposium probed the sources of barriers within special education that slow research utilization and of positive influences on attitudes toward conducting research in practical settings by illustrating successful partnerships and their findings. This document is an attempt to capture the session (in printed form). The first section presents five categories of barriers to the implementation of technology as outlined by the opening speaker, Dr. Joel Mittler. The second section describes four successful technology programs and factors that made them successful, as highlighted by the four opening-session speakers. The final section consolidates the thinking of the symposium participants, based on both verbal and written contributions during the process of identifying implementation barriers and more importantly, possible solutions.

Barriers to Technology Implementation

he use of computers in special education has been met with frequent criticism and skepticism. Many of the critics speak in terms of computers in the process of education while others speak specifically to special education. Regardless of perspective, the notion that the technology will fail as other technologies have failed in education is voiced by many. A close look at what is currently happening with the technology in special education provides insight, and maybe credibility, to their concerns but can also be used to help the field avoid traps that burdened previous technologies.

The three scenarios presented here illustrate recognizable teachers, teachers that the field is relying on to implement the technology. The federal government has invested a large number of resources in researching the use of technology with individuals with disabilities and legitimately asks why the findings are not affecting the classroom. The field needs to critically examine what stands between the research effort and the utilization of research information in the classroom to ensure appropriate use of the available technology.

A close look at the use of computers in special education provides insight, and perhaps credibility, to the concern that this technology, too, shall fall in education, but it also provides guidance on avoiding the traps that burdened previous technologies.

Scenario #1

A teacher says about technology: "I don't need that kind of stuff. It won't work in my class. You don't expect me to learn all that, do you? I don't have enough time to do what I do now and I've been teaching for 25 years without technology. No one ever told me I wasn't doing a good job. Just leave me alone."

Scenario #2

Another teacher talks enthusiastically about a course in computer science she took and about reading the latest stuff about Mac II's and Model 50 PS2's. She knows all the advantages and differences of voices that are either converted to analogue or digital speech and about different mega-hertzes and the differences between Novell and Corvus and so on. She states that she can do anything with this technology but she wished she knew just what to do with it.

Scenario #3

In this final, hypothetical scenario, a teacher relates: "I have this computer at home and my son tried this new program on math facts. Then I tried it and loved it. So I took it into my class even though the kids really didn't need it. I knew

how to work it so all the kids started playing with it. It was so much fun, with the balloons going up and the kids adding up numbers and so forth that after they finished all their regular work, I let them use it. Well, the building Principal came by and became so excited about special education kids finally using a computer that he called in the Director of Special Education and said, 'Thank goodness someone on my staff is using computers after I spent all that money last year.' He called in the Assistant Superintendent and the Director of Educational Technology. They came in and the Superintendent came by. She called in the School Board President. I went before the school board and showed them how to run this math program. And you know what? They made me Director of Special Education Technology.

So I went out and I bought 50 copies of this math facts program. I showed all the teachers how to use it, even if they didn't need it. I thought they would all be using it. But you know what happened? I met so much resistance—everywhere I went teachers would tell me all the reasons they weren't using it. About 6 months later when I passed by the rooms, I saw all their computers gathering dust in the corner."

None of these situations, though imaginary, are far-fatched considering the current state of efforts to implement technology in special education. Why is this? Why are these implementation efforts in such disarray? This paper begins the examination process and presents four examples of successful technology implementation.

A Common History

Technology in the schools has a longer history than many people realize.

Technology in the schools has a longer history than many people realize, and an analysis of this history can offer insight on current barriers. In his recent book, *Teachers and Machines: The Classroom Use of Technology Since 1920* (1986), Larry Cuban of Stanford University describes teachers' responses to technology in their classrooms since 1920. Cuban (1986) offers a telling 1922 quote from Thomas Alva Edison:

> I believe the motion picture is destined to revolutionize our educational system and that in a few years it will supplant largely, if not entirely, the use of textbooks. ... I should say that on the average we get about two percent efficiency out of schoolbooks as they are written today. The education of the future, as I see, will be conducted through the medium of the motion picture ... where it should be possible to obtain one hundred percent efficiency. (p. 9)

Edison showed much the same optimism about motion pictures that many of us feel today about computer technology. Yet many teachers never used motion pictures and, of those that did, the majority used them only occasionally. Survey after survey of teachers showed the following obstacles to increased film use: teachers' lack of skills in using the equipment and film; cost of films, equipment, and upkeep; inaccessibility of equipment when needed; and finding and fitting the right film to the class.

Looking at another form of technology that entered the schools, Cuban (1986) quotes William Levinson, who wrote in 1945:

> The time may come when a portable radio receiver will be as common in the classroom as is the blackboard. Radio instruction will be integrated into school life as an acceptable educational medium. (p. 19)

Radio, like film, failed to gain a foothold in the classrooms of America, according to a 1941 survey of principals reported by Cuban, for the following reasons: no radio-receiving equipment, school schedule difficulties, unsatisfactory radio equipment, lack of information, poor radio reception, programs not related

to the curriculum, class work more valuable, and the teachers were not interested. These reasons appear similar to some of those given for the barriers to computer technologies in today's classroom.

A third technology, instructional television, introduced in 1954, was seen as a solution to a perceived teacher shortage as well as a means of improving the curriculum. In some places it was used as a major means of delivering instruction; but overall, the initial use of television was dismally low, with greater use seen in elementary classrooms. However, with the production of a growing number of excellent documentaries available on videotape and the recent introduction of Channel 1, the instructional use of television may soon increase, regardless of its clouded past.

It is evident, however, that technology is not being used as it should be, and the reasons for its misuse or lack of use require investigating. A rough estimate indicates that less than 10% of the special education teachers are so enamored with technology that they will read about it, learn, and try all the latest ideas. Another 25% will say, "Go away, don't bother me." But the great majority of teachers are still undecided about technology. If this majority decides not to incorporate technology into their curricula, the work of researchers and developers, to date, may be for naught. Efforts to improve special education instruction may be lost if this group does not recognize and use the potential of the technologies. By recognizing the barriers that exist, solutions can be found and some assurances made that technology will be appropriately implemented.

Barriers

The barriers or roadblocks to the implementation of technology can be organized into five categories: equipment, implementation issues, teacher training, teaching profession, and traditional classroom operation.

Barriers to the implementation of technology in the schools come from five areas: equipment, implementation issues, teacher training, the teaching profession, and traditional classroom operation.

Equipment Barriers

The first obstacle represents problems with equipment. Some of these problems were noted by Cuban and are not uncommon to other equipment-intensive interventions. These include:

- Inadequate funding for hardware and software.
- Too much work required to manipulate the equipment—it is rarely as simple as it should be.
- New and complex skills required to use the newer equipment: New equipment often promises to simplify what we do but sometimes complicates things instead.
- Equipment does not work as expected.
- Available hardware is often obsolete.
- Equipment is unavailable when needed.
- Software inadequate to meet the needs of students: Some concerns are voiced that software drives the curriculum while others claim that curriculum drives the software.

Implementation Barriers

The implementation of special education technology requires planning and ongoing support. The following barriers, grouped as implementation issues, interfere with adoption:

- Schools lack both short- and long-term planning for technology integration.

- There is no financial support for teacher time and effort. A recent survey showed that 95% of the teachers using technology spend up to 10 hours each week beyond their regular responsibilities to learn the technology but only 20% of them get extra pay for their efforts.
- There is a lack of human resources to assist in the use of technology and in teaching with technology—few teachers have technical assistance available when it is needed.
- Administrators declare, "I bought it, you use it!" creating a problematic situation.
- The system may adopt technology, but the individual teacher may never use it.
- Token implementation or occasional use is insufficient for successful adoption of technology.
- Implementation is often done without teacher input.

Teacher Training

Teacher training issues are currently contributing to the poor implementation of technology in special education settings. The questions are: Should teachers be taught what they need for the classrooms of today or should they be taught the emerging technologies, with the latest hardware and software? Should the training curriculum address the expert or try to convert non-users to users? These and many other questions are still unanswered and they suggest the following specific barriers:

- The choice of what to teach is unclear.
- There is a limited supply of knowledgeable teacher trainers.
- There are various models for the delivery of knowledge in teacher training programs—specialist training programs, integration into methods courses, stand-alone courses but the most effective model is not known yet.
- Given the vast numbers of teachers trained over the past 5 to 10 years in special education, inservice education may be the only mechanism available.
- There may not be room for technology in the college pre-service curricula—other requirements are continually being added to the current curriculum, and there is little incentive to find room for yet another topic.
- More and more higher education faculty are using technology as productivity tools, but fail to use it in instruction—they are failing to model its use to preservice teachers.
- There is a difference between acquisition and performance. Even if the skills are acquired in training, there is no guarantee that they will be used.

Teaching as a Profession

Teaching as a profession presents a number of barriers itself. Through the course of their training, and even prior to training, teachers learn what it is to be a teacher. Certain traditions may be adopted, most often without the conscious knowledge of the teacher. These inherent barriers include:

- Teachers historically tend to value constancy of the school operation. Because they were students first, they are quite familiar with their job before they enter the profession, and they tend to value its beliefs and look to reaffirm them.

- The primary goal of teachers is to deliver instruction; technology is often viewed as incongruent with that objective.
- Technology is viewed as an end, not as a means to an end.
- Teaching is as much an art as a science; technology is seen by some as strictly scientific, limiting the art of teaching.
- Teachers value interpersonal relationships with their students; computers are often seen to replace the teacher-student relationship with a student-machine relationship.
- Technology is seen as just another bandwagon, and many teachers do not want to be on it.
- Technological change should be teacher initiated.
- Teachers are trained in content, not problem-solving skills.
- Teachers see no reason to adopt the technology—it has yet to be shown effective.

Classroom Environment

Within the classroom environment, many things compete for the teacher's attention—technology is just one.

- With so many things competing for a teacher's attention (e.g., IEP process, behavior management, teaching content, reports, etc.), he or she may not have the time or desire to get involved in learning about technologies.
- Certain routines and behavior patterns emerge that deal with the requirements of teaching; that is, using the question/answer format.
- Textbooks, chalkboards, and workbooks are the accepted materials to deliver instruction; they are cheap, portable, and flexible.
- Teachers typically deliver instruction in group settings—computers are seen as inconsistent with that approach.
- Teaching takes place in fairly stable, predictable physical setting—technology threatens that stability.
- Time allocation is stable and fixed—that is threatened by technology.
- There are established classroom rules and procedures for both students and teachers.
- It requires too much work to change teaching strategies.
- It requires too much work to identify appropriate software.
- Teachers have been oversold on ease of use of technology—it is not always as easy as we would like it to be, it does not always work, and problems reinforce all of the reasons not to use it.
- Teachers guard autonomy in making curricular decisions.

The following four sections relate some of the experiences of leaders in the implementation movement. Their varying perspectives offer insights into the complexity of the barriers facing full implementation of technology in the classrooms and the concomitant issues of both conducting and implementing research in the schools—important issues in light of the rapid development of technology.

Special Educator Characteristics. The barriers listed above are not all true for all teachers and are not equally true. Some barriers are more significant than others, but they are not insurmountable. By the fact that they do exist in some degree is a concern, and the field's ability to overcome them must be examined. The outlook is optimistic, however, because there is a parallel list of special education

Not all barriers exist in all situations and all are not equally true; moreover, special educators may be more open to the use of technology than regular educators simply because of their training and the nature of their teaching.

technology promoters for using the technology with disabled individuals. In fact, special educators may be more open to the use of technology than regular educators simply because of their training and the nature of their teaching. The following are some reasons this may occur:

- Special educators are less afraid of technological devices—they work with many devices already, such as wheelchairs and hearing aids.
- Special educators appreciate good behavioral instruction as is often exhibited in good software.
- Special educators use a variety of approaches to instruction—if that means technology, then so be it.
- Special educators bring less baggage with them to the classroom—they are younger, and the field is newer so they carry less tradition with them, allowing them to challenge old ideas.
- Special educators are used to modifying the educational setting and individualizing instruction.
- Special educators are used to using unique, modified, or different materials.
- Special educators think about efficiency, effectiveness, and attention to detail—many have been trained to collect data to make instructional decisions, and they may value the assistance technology can provide in that area.
- Special educators can get support from a number of existing information networks, user groups, and professional organizations that already focus on special education technology.

Critical Factors in Technology Adoption. While the stage has been set for the adoption of technology, there remain a number of critical factors that need to be addressed. These can be addressed through teacher training. They include:

- Providing ample practice on the existing technology found in the classroom.
- Using clear and validated teaching materials.
- Using credible sources to provide instruction.
- Adapting teacher instruction to their level of sophistication—being able to work with both experts and the uninitiated teacher.
- Demonstrating the value of technology for instruction in the classroom.
- Preparing teachers to adapt the technology to unique situations; e.g., training in the use of authoring systems.
- Providing time for teachers to learn and adapt the technology for individual use in the classroom by bringing in substitutes and providing administrative support.
- Encouraging collegiality—providing opportunities to share what they know.
- Providing focused ongoing inservice training.

Identifying strategies that may stimulate the adoption of technology is a difficult task. Some early ideas have been tried, and they are meeting some success, but not enough to pursue in isolation. For example, one strategy used by many was to teach all teachers how to use word processing and IEP software. It was thought that if the technology was a useful personal tool, then its usefulness in the classroom would be explored. Today, many graduate students use word processing, but are not using technology in the classroom. It is a good beginning, but other strategies must be implemented as well. Teaching teachers to use the computer to help solve their classroom problems may be a good next strategy.

If measures are not taken to facilitate the adoption of technology by trainers, the parents and students may begin demanding it. Administrators can help by

providing daytime training options, rather than adding the burden of learning to the end of teachers' already busy day. Providing human resources, as well as sufficient hardware and software resources will assist the adoption process. Allowing teachers to take the technology home on weekends and vacations to play with it and explore its potential may be the best strategy for getting teachers involved. This might be followed by forming special interest groups where teachers can share their new ideas—a strategy that will help support and maintain what they have gained through other strategies. Authoring software should be made available so teachers can individualize their instruction. Administrators should also reward users with time, conferences, recognition, and promotion for their extra efforts in technology. These strategies are only a few that might be implemented to supplement training efforts.

There's an old story about three types of people. The first group are those people who make things happen. There are many special educators that are already making technology happen appropriately in the schools, and they should be recognized. The second group of people are those who watch things happen. Many of us restrict ourselves to that group. Lastly, are those that wake up one day and say, "What happened?" There are too many special educators who will wake up one day and say, "What happened? What did we miss? Is it too late?" The task of the field is to let them know what is happening so they may become a part of it. ■

Implementing Technology in Special Education: Barriers and Promoters

he following four sections relate some of the experiences of leaders in the implementation movement. Their varying perspectives offer insights into the complexity of the barriers facing full implementation of technology in the classrooms and the concomitant issues of both conducting and implementing research in the schools—important issues in light of the rapid development of technology.

A View From the University

Dr. A. Edward Blackhurst is a professor in the Department of Special Education at the University of Kentucky. In this section he highlights both his work for the State of Kentucky and his findings from his broad university-based research. He closes with his solutions to the training barriers.

A Public Hearing

Recently I attended a public hearing on Kentucky's proposal in response to P.L. 100–407, The Technology-Related Assistance for Individuals with Disabilities Act of 1988. As a member of the proposal writing team, we were gathering public reaction to the priorities being established and the activities proposed to meet those priorities. A wide variety of people attended this meeting: people with disabilities, members of their families, advocates, and professionals.

Three major barriers to technology implementation were voiced by various participants at a public hearing in Kentucky: lack of trained personnel, of information, and of funds.

Interestingly, the first topic of discussion raised by the participants focused on barriers to greater use of assistive technologies. Three major barriers were identified and were addressed, in different ways, over and over again during the hearing. They were:

1. Lack of trained personnel. Personnel are needed who can conduct assistive technology assessments, implement technology programs, provide advice and technical assistance to consumers and their families, and implement research findings.
2. Lack of information. Knowledge is lacking of ways assistive technologies could help consumers with disabilities, their families, and those who were providing services to them and of available assistive technology services.
3. Lack of funds. Funds are needed to address the first two barriers and to purchase assistive technologies that can enhance the independence and quality of life of people with disabilities.

A National Survey

A few years ago, I assisted in conducting a national survey of 276 colleges and universities to inquire about how they were using technology and the barriers they were encountering in implementing instruction in technology in their training programs (Blackhurst & MacArthur, 1986). Eleven barriers were identified, with the following major findings confirming some of the barriers identified in the opening address:

- 89% of respondents indicated that faculty who were preparing teachers lacked skills to teach their students about technology.
- 85% of respondents said that their faculty not only lacked skills, they also lacked the knowledge about technology to adequately prepare their students.
- 94% of the respondents indicated that they had access to computers, but 87% lacked the fiscal resources to purchase the software that would be required to provide adequate instruction to their students.
- 82% reported that there was insufficient room in the curriculum to train their students about technology.

The study also found that faculty at most of the respondent institutions were using computers, but they were using them for their own professional productivity. That is, they were using them primarily for word processing and statistical analysis. We asked them what they felt were their greatest needs for faculty training. Interestingly, 82% said that they needed training about applications of technology for special education students, indicating that they lacked information about how to apply it to people with disabilities.

One conclusion from this study is that not only do we have a barrier in the lack of trained personnel, we also have a barrier with respect to people who are training those personnel. The data from this survey help to support some of the points made in the opening comments, however, the data are approximately three years old. The situation has undoubtedly improved somewhat in that time, but the colleges and universities are still inadequately equipped to do the job necessary to reduce the barriers imposed by the lack of training for special educators who are entering the job market at the present time.

A recent national survey concluded that we not only lack trained personnel, we also have a barrier with respect to the people who are training those personnel.

A Program for Success

I would like to propose several potential solutions to some of the training barriers that exist. First, we need to develop professional standards and guidelines for our special education professionals with respect to technology. In this vein, the American Speech-Hearing-Language Association (ASHA) has recently developed a draft set of guidelines for speech/language pathologists who are using assistive technologies to enhance communication. This is a very extensive list of knowledge and skills. These efforts need to be supported by other professional organizations that provide services to people with disabilities.

A second approach would be to translate the guidelines into certification and licensure standards. Kentucky has taken a rather interesting approach to this topic. Effective this year, all people graduating from a teacher preparation program must demonstrate a number of competencies in using computers. They must be capable of doing word processing, using database management and electronic spreadsheet programs, and using computers to generate graphics. They also must be knowledgeable about computer literacy, how to use computers in teaching, applications of keyboarding skills, and computer ethics. These standards have not gone quite far enough because they are restricted to computers and do not address other forms of technology. However, it is a step in the right direction. It is interesting to see how the Colleges of Education in Kentucky are scurrying to

One solution to the training barrier is the development of professional standards and guidelines which can be translated into certification and licensure standards encompassing identified skills and competencies.

meet these new regulations. (Of course, the state has not provided additional funds to the colleges to assist them with this task.)

A third solution is closely related to the first and second. The skills and competencies that practicing teachers and related personnel should have to use technology effectively need to be identified. Such lists can be used to establish priorities for in-service education, development of training packages, and by professionals to establish their own programs of professional development.

My colleagues and I have been addressing some of these areas. To date, we have developed technology competency lists for special education teachers, teachers of young children with severe handicaps, special education professors, regular class teachers, and administrators. There is a need, however, to validate such competency identification efforts. A five-step sequence is proposed here:

1. Conduct a task analysis (which is primarily what has been done to date).
2. Perform a social validation, in which knowledgeable individuals determine the competencies that are important and the relative importance of each.
3. Obtain reports of effectiveness of people who are demonstrating the competencies.
4. Conduct direct observation of people using technology to determine whether the competencies are appropriate.
5. Perform a "learner referenced evaluation." This is really the crux of the matter and involves determining whether people with disabilities learn better or perform more independently as a result of professionals having those skills.

The state of the art right now is such that the field is still working on the first two steps, with a few efforts being expended on the third step. This being the case, there is a long way to go before validated competency lists will be available.

Parenthetically, there is also a need to develop competencies in our teachers in the use of single-subject research methodologies to evaluate the effectiveness of technology interventions. Such methodologies can be done very effectively in the absence of control groups, because the subjects can serve as their own controls.

A fourth solution is that we need to infuse training into our teacher education curricula and into our in-service training programs. As noted elsewhere in this paper, there is a lack of consensus on the best approach to this topic at the preservice level. Should there be separate courses? Should there be an infusion into existing courses? It is my belief that a combination approach would be most effective. A separate course in the teacher preparation curriculum should teach the basics: computer operation, definitions, terminology, computer literacy, and so forth. Technology applications should be taught in the methods courses. Thus, when students take their methods courses, the professors will not have to get bogged down with basic topics, such as "This is Mr. Disk Drive." Students will already be able to use the technology in a meaningful way.

With respect to in-service, we conducted a project a few years ago that was funded by the Division of Innovation and Development of the Office of Special Education Programs. A consortium was established between the University of Kentucky and Fayette County Schools in Lexington, to study ways to integrate computers into the respective programs. One of the most effective strategies identified was to work with school principals. A computer was provided to an elementary, junior high, and senior high principal, they were trained in its use, and then were provided with ongoing support services. We found that they became advocates for computer use with their teachers.

Fifteen teachers were also included in this same study. When teachers got access to equipment and software, when they got the necessary training, when principals got access to the equipment and the training to use and understand the potential and requirements for effective use, implementation was greatly facilitated.

One final solution relates to translating research into practice. One area that both the the private and public sector should not overlook is the Small Business Innovative Research (SBIR) Program. This program of the federal government is designed specifically for the translation of research into practice. Government agencies have a portion of their budgets allocated for SBIR grants. The Department of Education has several, as do the Public Health Service and National Institutes of Health. Any small business is eligible for these funds. In many cases, university-based researchers collaborate with a small business to provide assistance to them in conducting such projects.

In closing, I believe that our challenges in technology training are several. I think that we need to determine the technology skills that we want our professionals to possess. We need to determine ways to structure the preservice curricula to develop those skills. We have to teach the trainers how to use technology, and we have to learn how to effectively in-service practicing professionals. Finally, we have to learn how to do all of this in a timely fashion.

A View From a Private Foundation

Dr. Steven L. Robinson is the director of the Educational Technology Research Program of The Amherst H. Wilder Foundation. In this section he relates the experiences and results of research conducted by the foundation in the local school district.

The Amherst H. Wilder Foundation is located in St. Paul, Minnesota, and has served the east metropolitan area of St. Paul for 75 years. Its mission, broadly defined, is to serve St. Paul children, youth, adults, and the elderly "in need." As a consequence of meeting service needs, Wilder has a long history of collaborative community service relationships in the community. One of the longer relationships has been with the St. Paul School District. The Educational Technology Research Program (ETRP) was one foundation program working in the schools to investigate a recent innovation in educational technology. The population of interest was at-risk, low achieving, and handicapped children. Unlike university and corporate research relationships, the usual focus of foundation activity has been service, not research and evaluation.

The Project

A private foundation in St. Paul, Minnesota, conducted long-term research in the city schools in exchange for which they provided in-house support for the technology introduced in the program.

Wilder's service focus influenced the focus of the ETRP. From the start, the goal was to facilitate the transfer of research into practice. To minimize stress on school teachers and students and maximize the transfer of what was learned from research, the foundation entered into an agreement with the school district to provide long-term in-house support. The ETRP provided the technology, consultation, and support in exchange for the collaboration and participation of teachers, students, and district administration. Technical and financial corporate support from 3M and the 3M Foundation was also a significant element of the program.

The innovative technology investigated was the Discourse® Educational Communication System. This system was designed to facilitate and help manage important classroom processes. Every student in a Discourse® classroom had a response device ("Studycom") consisting of a standard ("QWERTY") keyboard and a one-line (36 character) L.E.D. display. As students typed on their device,

what was typed was displayed on the teacher's computer screen. This allowed the teacher to ask an oral question to which every student could respond in his/her own words (20-25 words per question). All responses were immediately displayed on the teacher's screen. The teacher therefore knew which students had answered, and which had not and could quickly scan the answers of the entire class. The software provided full correction, feedback, recordkeeping, and media control (videotape, slide, graphics, videodisc) capabilities. Additionally, the technology permitted the teacher to conduct teacher-guided, student-paced, and multiple-group instruction.

Results

Results of the foundation research indicated that technology can be used to create a powerful instructional environment.

Research conducted over a 5-year period with over 100 teachers and 4,000 students from K-12 at five Discourse® sites indicated the technology could be used to create a powerful instructional environment. In general, research showed:

1. The technology could dramatically increase active student involvement and provide immediate correction and feedback, and performance monitoring.
2. Use of the technology in mainstream classes significantly increased the achievement of low achievers on standardized tests.
3. Models for effective instruction, (e.g., direct instruction) could be easily implemented with the technology with significant improvements in learning for handicapped children.
4. Additionally, teachers, administrators, and students were quite positive in their evaluations of ease of use and effectiveness.

Problems

The problems encountered over the duration of the ETRP were interesting as they relate to barriers for the implementation of technology in general. In the ETRP the biggest problem was not the process of research but the process of integration. Although the technology was in use by teachers and was viewed very positively, it was still quite difficult to move the schools and district to plan and provide adequate support and resources for independent operation. In the end, a major factor in the district's allocation of support was discussion about removal of the technology systems unless plans for adequate support were in place.

Another significant problem was the skill level of teachers. Although many teachers were thoroughly skilled in effective instruction techniques, many were not. We have found that training to use the technology is not as important as training in teaching. For example, in one study we found that teachers did not change their teaching behavior in the face of information delivered by the technology indicating students did not understand. Why? They confided that they did not know what to do. In other words, a major problem with technology and innovations in general is not learning to use the innovation, but knowing how to teach.

The idiosyncracy of classrooms, schools, and educational institutions was a third major barrier to integration. Research makes general prescriptions while teaching always deals with the particular. As one example, literature on school effectiveness consistently points to the importance of the principal. At ETRP sites, however, the effects of the principals were highly idiosyncratic. In one school, the principal and a few teachers were highly supportive. However, as soon as ETRP support was removed the teachers stopped using the system. What seemed to have happened was that since the initiative came from the principal, the teachers as a group would not support it on their own. At another school, the principal was almost totally uninvolved. Here the teachers were over-

whelmingly supportive, organized, and independent. The school now has three systems. The one consistent element at all sites has been the special education teachers. These teachers made things work for themselves and their students. They did not, however, have a major impact on the integration of the technology into their schools.

Another important discovery was that teachers were not interested in the research despite positive results with their own students. Their interest was in how the technology saved them time and helped them better manage a classroom. We found that any innovation that increased management chores would not be used no matter what the results. On the other hand, those that enhanced management with the same or less effort would be enthusiastically embraced. One reason for this may be that given the unpredictability of individual learning, teachers may be more interested in the process of instruction. Our conclusion is that achievement research is of more interest to administration. Teachers want and will use help about how to more effectively and efficiently manage classroom instructional processes.

In sum, working with schools is difficult but important. Schools quickly lose interest in accommodating to the restrictions of good research. However, schools will not effectively tackle innovation by themselves. They do not plan and provide adequate support because they do not have the time or resources to do so. The real issue is the development of alternatives to overcome disincentives to mutually beneficial long-term collaboration.

The Long View on Collaboration

Dr. Owen R. White, is a Professor of Education and Director of the Experimental Education Unit at the University of Washington, Seattle. Here he draws upon his knowledge of Washington State policy, his research experiences and even his family experience with instructive software to place in perspective the current state of implementing technology research in the classroom.

The State of Washington has before it a new referendum called "The Children's Initiative." As part of its grand scheme to improve the educational system in the state, there is a proposal to provide each child, from elementary through secondary school, with a portable computer—one that could be taken home each night. Although that section of the initiative is unlikely to make it all the way through the approval process, the fact that it has gotten as far as it has is encouraging. There is growing support for technology in education. The reality of "one child, one computer" may not be far away.

Patience and Small Steps

The goals originally set by the State of Washington did not include a landslide of technology into all schools at once. Rather, to fulfill more realistic ambitions, they worked primarily at the classroom level. The technology was brought into three or four "key classes" within a district. As those teachers became comfortable with the technology, they took it to other teachers, who in turn worked with still others. The result has been the development of a "grass-roots" network of support for technology in the classroom, and more recent programs designed to promote widespread innovation are being met with greater enthusiasm.

The State of Washington began a program where technology was introduced into three or four "key classes"; those teachers took it to other teachers and so forth until a "grassroots" network of support for technology in the classroom was established.

Enhance and Extend

Technology should not attempt to replace what is already working well in classrooms. Often, in our zeal for the machine, we forget that much of what already exists is good. There is a tendency for educational software developers to build "teacher-proof" programs that replace the teacher and take over the child's in-

Some lessons learned along the way include the fact that technology should not attempt to replace what is already working well in the classroom.

struction. I believe that is inappropriate. While computers can do some things better or more efficiently than teachers, good teachers still do many things far better than any machine. Those skills should be recognized and respected. The emphasis in developing technology should be to *extend and enhance* teacher capabilities, *not* to replace them.

As an example, consider "Aimstar," a program that evaluates pupil progress, applies a set of decision rules, and makes suggestions regarding when and how a program might be modified to facilitate continued learning. In many respects, it is an elegant, well written program, and was voted by The Council for Exceptional Children to be the most outstanding piece of educational software in 1984. As a device to assist in training teachers to use a data-based decision-rule technology, it can be very useful. As an ongoing aid for making instructional decisions, however, it does little more than what a teacher with about 3 hours of training can do, and it does it more slowly.

Development efforts should be focused on products that reduce time spent on clerical or routine tasks like drill and practice, or extend the teacher's capability by performing tasks that they cannot easily perform. Examples might include the use of interactive instructional animation, or the application of highly sophisticated algorithms for the evaluation of pupil performances. In any event, technology should not be used to perform tasks that teachers already do quite well.

Small Curricular Elements

Integration of technology into existing curricula will meet with less resistance if components are divided into relatively small units.

Integration of technology into existing curricula will meet with less resistance if components are divided into relatively small units. In a recent project to develop computer-assisted instructional programs for mainstreamed high school science courses, for example, we found that teachers were unwilling to relinquish control over the content and sequencing of their curricula. Had we developed programs that required a particular sequence throughout the entire course, it would have been unacceptable to most teachers.

The strategy we eventually employed was to break the course down into 25 or 30 relatively small and independent units. Each unit takes only about 10 or 12 minutes for a pupil to complete, and teaches the basic terms, concepts, and vocabulary for a relatively focused topic. A teacher can then decide which units to use, and the sequence in which they will be used, without committing their entire curriculum to one program. That flexibility and respect for the teacher's autonomy went a long way in making the technology more acceptable and useful.

Suggest, Don't Dictate

Technology should allow learners and teachers to take responsibility for their own programs.

In keeping with the issue of autonomy, programs should allow learners and teachers to take responsibility for their own programs. Dictating to teachers or students what to do and when to do it rarely works, and often leads to deliberate attempts to defeat the system. I am reminded, for example, of an early attempt to computerize the Individualized Education Plan. The system adhered rigidly to an "approved" curriculum sequence, and required mastery at each step before allowing the next step to be selected as an instructional target. When a teacher wanted to skip a step, perhaps because of the pupil's individual needs and abilities, the computer wouldn't let him or her record that action. Teachers soon learned, however, that they could work around the problem by simply indicating that all lower steps had been mastered, even if that were not true.

To avoid such problems, systems should respect the decision-making capabilities of the user. For example, a program might suggest to a student that at least one more practice session might be helpful, but it should not automatically cycle into that session without the student's consent. Similarly, a program might suggest an instructional strategy to a teacher, but should also allow the teacher to reject that suggestion and indicate the action actually taken. Such a system might

even keep track of the teacher's success when the computer's advice is rejected, and modify its own rule structure accordingly—adding the teacher's ideas to its list of suggestions when they prove successful, or becoming more "forceful" in its own suggestions when a particular teacher-generated strategy has repeatedly failed to work in the past.

Include Everyone

Much of the technology originally developed to meet the special needs of students with handicaps can also benefit "normal" students in mainstreamed settings. Restricting the application of technology to children with special needs singles those individuals out as "different," can make scheduling difficult, and arbitrarily limits the potential impact and benefit of the technology.

Much of the technology originally developed to meet the special needs of students with handicaps can also benefit "normal" students in mainstreamed settings.

For example, our project to develop computer-assisted-instruction (CAI) modules for mainstreamed secondary science courses had originally planned to involve only students with learning disabilities. The teachers, however, believed that the program would probably benefit all their students, and that it was simpler to schedule the entire class into the computer lab once a week than to arrange for individual sessions. They were right, of course, and were much more receptive to the program because it benefited everyone in their class, not just a few.

Equipment

One barrier frequently encountered when trying to conduct research or development in public schools is the lack of appropriate equipment, or the inconsistency of equipment available at different levels in the public school system. For example, Tom Lovitt of the University of Washington completed a series of successful CAI studies at the secondary level, and wanted to extend his work to the elementary level. Unfortunately, while the Macintosh was the computer of choice at the secondary level, old Apple II's or the newer Apple II GS's were the systems most frequently found at the elementary level. It appeared that Lovitt would have to rewrite all of his programs to run on the Apple II series. That would take time, of course, and additional expense. Most importantly, however, he was reluctant to move to an inferior machine, which would probably place limits on what his programs could accomplish. Instead of spending his money on reprogramming, therefore, he spent it on Macintoshes, and moved them into the elementary schools. That approach yielded many advantages.

One barrier frequently encountered when trying to conduct research or development in public schools is the lack of appropriate equipment, or the inconsistency of equipment available at different levels in the public school system.

First, he lost no time in reprogramming his courseware. Second, the schools were obviously delighted to participate in his research since they gained access to a more advanced technology, at least for the duration of the studies. Third, once the research began to demonstrate the usefulness of the technology, the schools were more motivated to find the resources necessary to purchase that technology themselves. While most of us have tended to address the capabilities of the equipment already found in the schools, Tom has shown that it might be better, at least in some cases, to use the best technology available, and show the schools what it can do.

Living Down Our Past

For me, perhaps the single greatest obstacle to moving technology into public schools is a result of early software development efforts. Many, if not most, early attempts to develop courseware were poorly conceived, often addressed only trivial needs, and almost always ignored what we know about good instructional practices. For example, my own son worked with a program called "speller bee" some years ago. At first he was intrigued with the program, and struggled long and hard hours with it. Eventually, however, a number of facts became clear.

Advocates of technology in the classroom must be careful to encourage the use of only those programs which we know are based on sound instructional principles.

First, it took 30 to 45 minutes for him to enter each week's spelling list and to edit the phonemes so the computer could speak the words correctly. Secondly, it was not a rule-based system, and could give no differential feedback concerning various types of errors, or even where in the word he went astray—words were either all-right, or all-wrong. Third, if he spelled a word correctly, he had to wait while the program drew a picture of a little bee, and then flew it merrily around the screen for 5 or 6 seconds. That was cute the first two or three times it happened, but grew very old very fast. Finally, the program showed no patience. Since my son had not yet developed fluent keyboarding skills, he was often still looking for a particular letter when the program decided he didn't know the word, scored the word as "missed," and moved on to the next word in the list. He correctly concluded that his time was better spent in other activities.

Those teachers who "pioneered" the use of CAI in their classes in the not-too-distant past saw one after another of their students fall prey to poorly designed software. Getting those teachers to try again can be difficult. We can speed the process only if we are very careful to encourage the use of only those programs which we know are based on sound instructional principles, and that perform tasks which teachers would otherwise find difficult or time-consuming. Above all, we must show restraint in our claims for technology, and promise only that which we know we can deliver. Broken promises are long remembered, and the distrust they breed can be very difficult to live down.

A View Into the Classroom

Harriet Copel is the teacher coordinator of microcomputer applications in special education at BOCES 2, on Long Island in New York. Her experience as a direct service provider with an intermediate unit has given her a unique outlook on the state of technology implementation in the schools and the sources, frequently valid, for teachers' resistance to research in the classroom.

The BOCES 2 Special Education Division of New York is an example of an agency which has successfully integrated technology in its instructional programs. The staff are direct service providers who have successfully overcome some of the barriers mentioned in the previous sections of this paper. Many barriers of access to hardware and software have been eliminated, staff development has been extensive, and the focus now is on improving the classroom environment with the use of technology. In our attempt to improve the learning environment, we have engaged in several limited research projects which have led me to make some caveats on teacher participation in research.

The Art of Teaching

In the classroom, teachers naturally guard their autonomy in making decisions; researchers who wish to enter their domain must first establish a level of trust to make a program successful.

Several obstacles appear when trying to both conduct and use research in the classroom. Excellent teachers are masters at working in an environment where there are many variables which cannot be controlled. Being able to successfully manage a classroom is the "magic" and "art" of teaching. Researchers who wish to enter the teacher's domain, and control some of these variables, will run into serious resistance.

Teachers guard their autonomy in making decisions. They guard their freedom to try a variety of instructional and behavior management techniques. The researcher, appearing judgmental or evaluative, may threaten and/or inhibit the spontaneous, flowing actions and decision making of the teacher. To minimize this obstacle, a level of trust must be established, between the service provider and the researcher, prior to the onset of the research.

Politics are Everywhere

The school environment is a political system with union politics, administrative politics, teacher-to-teacher politics, paraprofessional politics, and parent politics. When the researcher finds a primary supporter within the agency, the objectives of that individual or office should be known. His or her motive will strongly influence the manner in which the researcher will be received within the classroom.

If the investigator's primary backer is a classroom teacher, then the task of gaining support and encouragement from the resource people, administration, and parents is critical. Specifically, research in the use of technology within special education requires that the technical support people are made available on an "as needed" basis to support the teacher and students who are using the equipment.

Is It Worth the Bother?

Teachers do not necessarily want someone to come into their classrooms to study something which they already know they do well or a phenomenon that they already know exists. A common response from a teacher might be, "This has worked; I know it works. That's great. Why bother to come in and study it? I'm not going to read that article, I already know the conclusion." To gain the cooperation of a teacher whose classroom practices the researcher wishes to study, the researcher should offer something that benefits the teacher. Sometimes it is as simple as engaging the teacher in conversation to see if there are questions or problems she may have that the researcher can help with.

To gain the cooperation of a teacher whose classroom practices the researcher wishes to study, the researcher should offer something that benefits the teacher.

Another way to gain teacher support for implementing new or experimental techniques in their classroom is to involve them at the conceptual level—either in research or in product development. Teachers might well welcome the opportunity to pilot regular education software and provide feedback to the developers on adaptations which would make the product serve a broader audience. Through the process of combining researchers, product developers, and practitioners, all three parties might arrive at answers to some of the many questions about the effective use of technology in special education. In any case, teachers need a tangible motivator to encourage them to make the extra effort and take the extra risk of allowing research in their classroom.

A problem also occurs when selecting teachers to participate in research studies. After choosing the finest group of teachers for a research project, the remaining teachers, "not the finest" by definition, are left for the control groups. This makes it difficult to form control groups; yet, without them, the researcher may not be able to present a convincing argument that the technology improved the instruction, not the selection of the participants.

Gaining Access to the Tools

Access to the technology on which much research is based can be a problem for teachers. One example is telecommunications. In our agency, every teacher has at least one computer in the classroom, but not one has direct access to a phone line. Many fine distance-learning, pen-pal, and data-collection telecommunications projects exist, and much attention has been given to them in the literature. Yet most teachers cannot use these projects. We are not allowed to empower teachers to use the phone system nor are many teachers permitted access to bulletin boards because the material has not been screened or previewed by an administrator.

Discovering what motivates the individual teacher and how technology can help will ultimately unlock the barriers to successful research and implementation in the classroom.

Summary

Perhaps we all need to follow the advice of the Indian saying and "walk one mile in another's moccasins." Certainly researchers need to be aware of the unique perspectives and problems of the classroom teacher. Discovering what motivates the individual teacher and how technology can help will ultimately unlock the barriers to successful research and implementation in the classroom.

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Barriers and Potential Solutions for Moving Technology Research Into a Practice Setting

The fifth annual technology symposium of the Center for Special Education Technology focused on *Advancing the Use of Technology: The Research/Practice Connection.* Held in June 1989, the invitational symposium included knowledge producers (researchers) and knowledge users (practitioners). Practitioners were broadly defined to be those who were in a position to apply research findings to educational practices and programs for children with disabilities or to product-development efforts.

Participants were asked to share their thoughts and experiences related to the transfer of research-based knowledge into the practice setting. Specifically, they were asked two questions:

1. What barriers have you encountered in moving research into a practice setting?
2. What are some solutions to bridging the gap between research and practice?

This document summarizes their responses in the hopes of encouraging researchers and practitioners to move beyond existing barriers by incorporating some of the potential solutions suggested by the symposium participants.

Problems in Moving Research Information Into the Practice Setting

Research Problems

Research was defined as the process of conducting research and the dissemination of the findings. Research conducted in the practical setting translates more easily into practice, but it presents numerous research methodological problems: It is a time- consuming, lengthy process to identify research sites, gain access to them, and collaborate during the research and dissemination process; research variables are easily contaminated in uncontrolled settings; and alternative research designs for practical settings are not available or as acceptable by the research community. Findings of studies frequently reach the field too late and are not useful: The process of dissemination through journals is slow; research is

seldom reported in practical terms or translated as to their implications for practice; and there are many gaps in the research-base for specific special needs audiences.

Collaboration Problems

Collaboration was defined as researchers and practitioners working together during the planning, research, dissemination, and implementation stages. There is limited communication and collaboration between researchers and practitioners. Researchers often have a narrow perception of school issues, failing to see the implications of their recommendations. Not all personnel share the vision of technology and resent its intrusion into their plans and classrooms. Willing personnel often resist collaboration because of the lack of time and support needed for involvement. Administrative responsibilities for collaboration are unclear. It also requires a different level of planning and organization on the part of the school administrator.

Training Problems

Training was defined as ensuring that school personnel are knowledgeable in technology and research in order to be practical partners in the research and implementation process. The inadequacies of teachers in the area of technology is attributed to the lack of training at both the higher education and local school district levels. Higher education faculty, themselves, are not adequately trained in technology and therefore cannot train others, and they do not prepare perspective teachers well enough in the basics of effective instructional strategies for these skills to generalize to technology applications. Local school districts do not have the resources to provide ample inservice training, which includes money to train the trainers or the provision of release time for teachers to attend training workshops.

Funding Problems

Funding was defined as obtaining money and other resources for research and implementation related activities. There is a lack of adequate funding for a broad range of technology-related activities including research, training, state-of-the-art equipment purchase, marketing research, and product development. Too few education grants are available and present funds are being cut, eliminating many inservice training programs.

Technology Problems

Technology was defined as computers and related equipment. The technology itself presents many barriers to the research and translation process. The equipment currently in schools has limited capabilities, research is frequently conducted on more capable equipment with little support for the older, and there is a lack of compatibility between the two. The requirements of the special needs population are very diverse, and it is difficult to adapt the existing systems to their needs. The cost of the technology prohibits the schools from upgrading as rapidly as the field would like. There is also little awareness of the capabilities of the newer emerging technologies such as videodiscs.

Implementation Problems

Implementation was defined as the appropriate application of technology and its related research into the special education classroom. School personnel, including administrators and decision makers, frequently do not support the use of technology and are resistant to incorporating research findings. This is in part due to a lack of awareness of the potential benefits of technology and awareness of resources and supports available. Strategies incorporated within off-the-shelf instructional programs are often not compatible with the instructional approach

of the teacher, and it requires too much time for teachers to author the complex instructional programs they need. There is also a lack of hardware, software, space, technical assistance, and other resources, coupled with inefficient scheduling, to provide the teachers with enough access to make the technology work as a beneficial medium for instruction.

Potential Solutions

Symposium participants suggested many ways to bridge the gap between research and practice. Their solutions are presented here according to who the responsible initiator or change agent might be. The categories are used only to help stimulate thinking and more easily identify activities that a specific audience group can do to encourage the transfer of research information into practice.

Shared Responsibilities For Change: Researchers, Practitioners, Developers

- Encourage the acceptance of research synthesis articles in professional journals that could facilitate the development of products and the transfer of research into practice.
- Solicit support on the local school level by helping teachers and administrators share visions of what technology can do for students.
- Pursue research partnerships with industry, government, universities, and schools.
- Create opportunities for frequent dialog between researchers, faculty, developers, administrators, and practitioners (e.g., users groups, symposia) to share perspectives, transfer research information into practice information, conceptually design products, and keep informed.
- Establish and strengthen links with the rehabilitation community.
- Create shared responsibilities through joint projects between universities and schools.
- Seek additional funds for training from the federal, state, and local levels.
- Provide training programs that reflect the general growth of teacher skills in order to train beyond just proficiency, allowing teachers to explore with the technology.
- Write more grant proposals and seek collaboration with equipment developers to obtain the necessary equipment for training and research.
- Provide financial assistance or incentives to developers to produce technology products for special education.
- Encourage the development of more inexpensive computers that can be linked together.
- Encourage more efficient and effective use of available technology in the schools.
- Build better information networks between schools, especially reaching rural areas.
- Encourage government support for requiring computer literacy for special education students.
- Link technology to the curriculum.

Areas of Change by the Federal Government

- Encourage funding agencies to require components on practitioner and developer collaboration.

- Tie funding to cooperative efforts or partnerships between universities and schools to encourage better applied research and faster transfer of research into practice.

Areas of Change by Researchers

- Develop and/or incorporate alternative research designs that are more school-based and problem solving, with multi-year interventions that accommodate slow change in schools.
- Specify practice-oriented products from each research project.
- Work within the school environment to recognize characteristics and demands of the setting and learn to accommodate research to address the needs of the practice setting.
- Address specific research areas such as cost effectiveness, skill acquisition, social interaction with peers, and movement to less restrictive educational and vocational environments.
- Report research findings through the symposium format and other alternative forums for timely dissemination and include practitioners as well as researchers.
- Build in adequate dissemination, translation, and implementation phases into every research project.
- Investigate the use of video technologies for faster dissemination of research information.
- Involve administrators and teachers in the research planning and decision-making process, including at the research-question formulation stage.
- Encourage the development of needs-based product designs by including the special education practitioner in the planning and design stages as well as in the field-test stage.
- Give ownership of the research to the schools and use the technology as a natural bridge between research and practice.
- Build teacher skills during the research so they can continue implementing the technology after the project ends.

Areas of Change by Higher Education Trainers

- Establish higher competencies in effective instruction, technology, curriculum integration, research methods, and product development for preservice teachers.
- Retool higher education faculty in technology so they may provide more training through their institutions.
- Conduct preservice and inservice technology training based on research and the transfer of research into practice.

Areas of Change by School-Based Personnel

- Increase administrative support and organize the collaboration between researchers and practitioners to include a staff liaison.
- Provide practitioners with the time and opportunity to read and discuss current research with other practitioners and researchers.
- Encourage knowledgeable administrators to become facilitators of technology integration and provide tangible rewards for their efforts in collaboration and cooperation.
- Provide release time and inservice training so teachers can become knowledgeable partners in research on computer-assisted instruction.
- Broaden the use of middle management personnel and other local professionals who are familiar with the technology and educational practices, for

the purpose of providing training, technical assistance, and serving as resources.

- Establish in-house technology staff and study groups at the local school level to provide teacher support.
- Channel funding to provide support for teacher release time and summer institutes to obtain the necessary training.
- Encourage the use of personal computing in classroom activities.

Areas of Change by Product Developers

- Design research-based products on affordable equipment and develop clear and thorough documentation to show its purpose and appropriate implementation.
- Work with practitioners in the early stages of product development. ■